EP1.89/2:600/S2-84-188

United States
Environmental Protection
Agency

Water Engineering Research
Laboratory
Cincinnati OH 45268

Research and Development

EPA-600/S2-84-188 Dec. 1984

EPA

Project Summary

Recommended Practices for Flow Measurements in Wastewater Treatment Plants

Gershon Kulin

A series of three short, concise manuals were produced to provide improved guidelines for the selection, installation, calibration, and maintenance of instruments used for monitoring and control of flow in wastewater treatment plants. Material and information are brought together from several sources and placed in an easily referenced format. The documents include the following:

- **Recommended Practice for the Use of Electromagnetic Flowmeters in Wastewater Treatment Plants.**
- **Recommended Practice for Flow Measurement in Wastewater Treatment Plants with Venturi Tubes and Venturi Nozzles.**
- **Recommended Practice for the Use of Parshall Flumes and Palmer-Bowlus Flumes in Wastewater Treatment Plants.**

Each document is prefaced by an executive summary, briefly answers several of the most common concerns expressed by treatment plant personnel, and references the specific section of the document that covers the topic in detail.

This Project Summary was developed by EPA's Water Engineering Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

Flow measurement is the most commonly measured parameter in wastewater treatment plants and is required for several diverse purposes, including permit reports for the National Pollutant Discharge Elimination System, billing, the design of new facilities, and in-plant process control. Moreover, the devices used to measure flow are even more diverse and have completely different geometries, principles of operation, installation requirements, effective measuring ranges, and uncertainties of measurement (accuracy).

Three short, concise manuals were developed to summarize the key information required for:

- Selection of the proper device for an application
- Installation design
- Operation and maintenance requirements
- Calibration procedures

The information presented in the manuals also includes the principles of operation for each device and several means of verifying the calibration of an installed flowmeter.

Scope of Recommended Practices

Meters

The material in the three documents covers classical venturi tubes, venturi nozzles; magnetic flowmeters, magnetic probes in circular pipes flowing full; and

BEST COPY AVAILABLE

Parshall and Palmer-Bowlus flumes are open channel flow measurement. These devices can be used to measure influent wastewater, treated effluent, raw sludges, digested sludge, and activated sludge. The advantages and disadvantages of each type of meter are discussed along with the construction, configuration, and installation of the primary elements; the secondary installation requirements; and methods of checking performance and calculating errors.

Installation

The care used in the installation of any flow-measuring device is critical to both the accuracy of the flow measurement and the ability of operating personnel to maintain the flow meter in optimum condition. This fact is illustrated by the installation requirements section of the manual on magnetic flowmeters.

Approach Conditions

At least five diameters of straight pipe, measured from the plane of the electrodes, should precede and follow the tube. Even when this approach length requirement is met, errors will be introduced by severe upstream disturbances. The magnitude of the errors will depend on the magnetic flux distribution incorporated in the particular design.

If a manufacturer claims less sensitivity to disturbed flows or if approach lengths shorter than five diameters are recommended, data and/or a description of the experiments or analysis on which this recommendation based should be furnished to the user.

An exception to these requirements can be made in the case of a tapered, axisymmetric reducer, which is installed immediately upstream of the flow tube to provide a self-cleaning velocity within the flow tube. The included angle of such a taper should not exceed 30 degrees, either upstream or downstream of the flowmeter.

Bypass

We strongly recommend that piping and isolation valves be installed in such a way that the flow can bypass the meter. Such an arrangement permits both removal of the meter for servicing and convenient stopping of flow through the meter for zero checks.

We also recommend that a cleanout tee be installed near the flow tube (see Figure 1 for one suggested layout). This accessibility is particularly important for meters that do not have electrode-cleaning capability or are subject to deposition or coating.

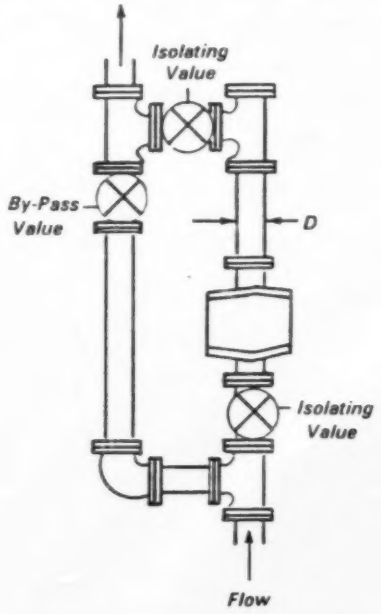
Orientation and Location

The flowmeter should preferably be installed in a vertical length of pipe. This orientation tends to equalize wear on the lining when an abrasive liquid is flowing, and it also prevents gases from collecting at the pipe crown. If the flowmeter cannot be placed in a vertical pipe and must be inserted in a horizontal or inclined line, the following steps are recommended:

- Orient the meter so that the electrodes are on a horizontal line.
- If the pipe is horizontal, install bleed valves at the crown near the flowmeter so that the line can be checked for accumulated gas.
- In any event, locate the flowmeter so that it will remain full, both during flow and when the flow is stopped.

Limiting Velocities

To assure scouring action, design from minimum velocities of at least 1.5 m/s (5 ft/sec) for primary sludge and at least 0.9 m/s (3 ft/sec) for other sludges and raw influent sewage. To avoid excessive abrasion, velocities should never exceed 8 m/s (25 ft/sec).



Note: Recommended 5 D Up and Down Stream

Figure 1. *Typical installation.*

Other Considerations

Place the flowmeters on the high pressure side of pumps and control valves to minimize the effect of gas bubbles. Avoid proximity to heavy induction machinery. Proper grounding is essential.

Even when the flow device is correctly installed, the measuring system should be checked for uncertainty of measurement and estimated errors should be recorded. Error estimates provide an assessment of the uncertainty of a measurement. One method of estimating the uncertainty of a flowrate determination based on the principles of a venturi tube is to combine individual uncertainties as follows.

$$\delta Q/Q = [(\delta C/C)^2 + M^2(\delta D/D)^2 + N^2(\delta d/d)^2 + (1/4)(\delta \Delta h/\Delta h)^2]^{1/2}$$

where $M = 2\beta^4/(1-\beta^4)$

$N = 2/(1-\beta^4)$

δ = uncertainty

d = throat diameter

Δh = differential head on meter in terms of height of the flowing fluid

C = flow coefficient

D = inlet diameter

Q = volumetric flowrate

β = diameter ratio, d/D

The second and third terms inside the brackets are usually small, since the diameter uncertainties are limited.

Volumetric Method

Verification of flowmeter accuracy becomes more difficult with increasing size. For small meters of 7.5 cm (3") or less, it is usually possible to set up a means of diverting the flow to a tank of known geometry so that the accuracy of the meter can be checked volumetrically. Even for large meters this is still the preferred method; but if this technique is not possible, alternate methods can be used.

Dilution Method

In the dilution method, the flowrate is deduced from the dilution of measurable

BEST COPY AVAILABLE

properties (e.g., color, conductivity, or fluorescence) of tracer chemicals added to a turbulent flow in known amounts. The calibration can be done either by the constant-rate injection method or the slug injection method. The constant-rate method is recommended here because it appears to be more practical for in-plant use. In the constant-rate injection method, a tracer solution of accurately known concentration is injected upstream at a rate that is constant and accurately measurable. At a downstream distance long enough for complete mixing, the flow is sampled and the concentration determined after a steady state of concentration "plateau" is attained. The flowrate, Q, is then determined from

$$Q = q(c_1 - c_2)/(c_2 - c_0)$$

where q = the rate at which the sample of concentration c_1 is injected,

c_2 = the measured "plateau" concentration downstream, and

c_0 = (which may be close to zero) = the background concentration of the tracer chemical existing in the flow.

This method requires accurate measurement of q and of all concentration. Skilled personnel and specialized equipment are needed, but under optimum conditions, the potential accuracy is high.

The tracer property must be conservative, since losses by absorption to solids in the flow will result in an apparent reduction in c_2. The fluorescent dye Rhodamine WT has been used successfully in sewage without losses, but its behavior in sludge is not known.

These recommended practices were prepared in fulfillment of Interagency Agreement No. 78-D-X0024-1 by the National Bureau of Standards under the sponsorship of the U.S. Environmental Protection Agency.

Gershon Kulin is with the National Bureau of Standards, Washington, DC 20234.
***Walter Schuk** is the EPA Project Officer (see below).*
The complete reports, entitled:

"Recommended Practice for Flow Measurement in Wastewater Treatment Plants with Venturi Tubes and Venturi Nozzles," (Order No. PB 85-121 663; Cost: $10.00)

"Recomended Practice for the Use of Parshall Flumes and Palmer-Bowlus Flumes in Wastewater Treatment Plants," (Order No. PB 85-122 745; Cost: $10.00)

"Recommended Practice for the Use of Electromagnetic Flowmeters in Wastewater Treatment Plants," (Order No. PB 85-122 737; Cost: $8.50)

The above reports will be available only from: (cost subject to change)
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: 703-487-4650

The EPA Project Officer can be contacted at:
Water Engineering Research Laboratory
U.S. Environmental Protection Agency
Cincinnati, OH 45268

☆ U.S. GOVERNMENT PRINTING OFFICE: 559-016/7873

BEST COPY AVAILABLE